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ABSTRACT

An internal cognitive variable--mental imagery representation--was studied using a set of three information-processing strategies under external stimulus visual display conditions for various learning levels. The copy strategy provided verbal and visual dual-coding and required formation of a vivid mental image. The relational strategy combined dual-coding with a peg-mnemonic memory procedure involving a set of pre-formed images. The hierarchy strategy combined the processing advantages of the other two strategies but involved encoding new information into a logical taxonomy. Visual stimulus complexity was examined using the visual portion of three slide-tape instructional presentations on the human heart, containing either line drawings, detailed color illustrations, or realistic photographs. Although all three strategies used imagery representations as an information-processing mode, they varied in the amount of cognitive organization imposed on encoded data. The hierarchy strategy resulted in the most effective learning, while the relational strategy was slightly superior to the copy strategy. The simple visual display was the most effective and efficient. (LMM/Author)

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Acceptance Presentation And
Research Study Summary:

RESEARCH IN EDUCATIONAL COMMUNICATIONS AND TECHNOLOGY

1982 Association For Educational
Communications And Technology
Young Researcher Award,
Research And Theory Division

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Introduction

Prior to beginning a summary of my research study, I would like to discuss a few ideas on significant current trends in educational research. Of specific importance to us are how these trends affect the research in Educational Communications and Technology.

Trends In Educational Research

The traditional research paradigm in Educational Communications, adapted from Experimental Psychology, has in the past been a Behavioral research orientation. However, the research orientation in Experimental Psychology and Educational Psychology is now radically changing from a Behavioral orientation, to a mentalistic or Cognitive orientation. Because of this it is becomming much more complex but yet, much more interesting and productive. A cognitive orientation to research opens up a variety of hypothetical and theoretical research questions that Behavioral Psychology simply did not consider, and in many circumstances, did not allow!

Looking at the history of Educational Communications and Technology research, one can easily see how our professional field fits "quite nicely" into a traditional Behavioral research paradigm. Behaviorism deals with the manipulation of the external learning environment, or external events, to cause some observable change in human behavior. Traditionally, this observable change in behavior, if relatively permanent, has been

operationally defined as learning by Behavioral Psychologists. In essence, Educational Technology has had as its primary orientation, in both research and practice, doing precisely this: "changing the external learning environment (e.g., learning conditions) through instructional technology, to cause learning to occur or to improve learning. While this Behaviorist research and practice orientation has been productive, it tends to leave an entire area of human learning untouched. This area of learning untouched by Behaviroistic research paradigms is the internal cognitive area, or the Cognitive Structure. Behaviorism simply does not seriously consider this internal cognitive area of the human learner, and does not attempt to explain learning and memory phenomena related to internal cognitive behavior (e.g., levels of processing - Deep vs. Surface Structures, mnemonic systems, cued/free recall, etc.).

Traditional Behaviorism referred to the cognitive structure as a Black Box, and the "father of psychology", Wilhelm Wundt, clearly stated that internal mental events were not open to empirical research. Wundt divided psychology into two divisions: "simple psychical processes", such as physiological reflexes and sensation which could be studied by direct experimental designs; and "higher psychical processes", which according to Wundt were, "too variable a character to be subjects of objective observation." Essentially, Wundt decreed that higher level mental processes could not be studied by observation, and, therefore, should not be studied. This type of classical Behavioristic attitude regarding research on human cognitive processes has

persisted to the present, but is no longer totally appropriate. Internal cognitive events, mentalistic events, have been theorized about, experimentally examined and experimentally manipulated, leading to improved learning and changed behavior in a number of empirical studies dealing with cognitive factors as independent variables. However, until quite recently, traditional Behaviorism has controlled experimental research in most serious research efforts about learning and instruction.

Wittrock noted in his AERA state-of-the-art address several years ago: "A cognitive approach implies that learning and instruction are scientifically more productively studied as an internally, cognitively mediated process than as a direct product of the external environment. The cognitive approach to educational research is involved with understanding the relations or interactions between the learner's cognitive processes and aptitudes; such as, attribution, motivation, encoding, memory, cognitive styles, and characteristics of the external environment or instructional treatments. Additionally, a cognitive research design for learning and instruction emphasizes the active and constructive role of the learner and is concerned with internal cognitive events not only external instructional events."

Finally (Wittrock), "In a Cognitive research paradigm instruction involves stimulating the learners information processing strategies, aptitudes, and stores of relevant specific knowledge in relation to the information to-be-learned."

For Educational Communications and Technology to remain in the forefront of educational research, it is no longer possible

to adopt only a Behavioral research paradigm, internal cognitive variables should be considered. However, one serious caution in this regard. A cognitive orientation is not rea-ly new, it is not a panecea, and it is not an area in which "we can generate endless adjectives of new jargon". Cognitive research is actually quite old, older than Behavioral Psychology, and really pre-World War II vintage. Can anyone tell me from what classical research paradigm Cognitive research stems, (Gestalt Psychology)? The majority of the research questions modern-day cognitive psychologists are considering, including cognitive learning strategies, can be found in the classic Gestalt psychologist's experiments. So before you get started in this area of research, read up on the Gestalt psychologists such as Kohler, Katona, Wertheimer, Wallas, Duncker, Luchins, and Birch. An excellent treatment on Gestalt psychology and cognition can be found in Richard Mayer's delightful text Thinking and Problem Solving, 1977.

Research Study Summary

The present investigation experimentally examined the internal cognitive variable of mental imagery representation in the form of a set of learning strategies, under external stimulus visual display conditions, for various learning (information processing) levels.

Internal variables are processes directly affecting the state of the cognitive structure during learning. Such processes range from: sequential and imagery mediation, assimilation and accommodation, accessibility and availability, encoding and decoding, insight, and lateral transfer, to such characteristics of the leraner as expectancy and cognitive style. Internal

processes are influenced or reflected in a number of learning strategies such as, paraphrasing, mathemagenics, hierarchical rules, concretizing, mnemonic memory techniques, and generative rules. Within the context of the present study, learning is synonomous with information processing. Additionally, learning has been operationally defined as a three step cognitive process of: abstraction, encoding, and retrieval. Abstraction is the selective perception of to-be-processed information, encoding is the mental storing of information and retrieval is the search and decision process leading to recall.

Both internal and external variables were considered in the present investigation, the specific internal variable of concern in this study was mental imagery mediation (e.g., imagery representation of stimulus events). The imagery mediation process was operationally related to a set of three information processing strategies that varied in the amount of cognitive organization they tended to impose upon information during learning. The three levels of the strategy variable were called the copy strategy, the relational strategy, and the hierarchy strategy.

The information processing advantage of the copy strategy is that it required the subject to form a vivid mental image of the perceived visual stimulus display. The development of the copy strategy was based upon the general research conclusion that imagery mediation facilitates learning due to the information processing advantage of dual-coding. Dual-coding is the multiple encoding of processed information into a sequential code (e.g., verbal trace) and a spatial code (e.g., imagery trace).

The relational strategy provided for the processing advantage of dual-coding as well, however, the relational strategy moves one step farther to facilitate information processing with the use of a peg-mnemonic memory procedure. A peg-mnemonic memory procedure will facilitate the assimilation and accommodation of to-be-acquired information by providing a pre-existing cognitive framework for the newly learned information. The peg-mnemonic technique employs the same process as a rhyme mnemonic, except the pre-learned conceptual pegs in this case were a set of pre-learned images instead of a rhyme. The psychological basis of this memory technique can be found in David Ausubel's "meaningful learning theory." Ausubel notes that relevant material being available in the cognitive structure facilitates the assimilation and accommodation of new information. Relevant available information will tend to provide a cognitive organizational framework that will facilitate the encoding of new information, allowing for meaningful learning rather than rote learning.

The hierarchy strategy had the processing advantages of both imagery mediation and a mnemonic memory system, however, an additional processing step is implemented by using this strategy. Subjects using the hierarchy strategy learned to place each bit of imaged information into a logical network of interrelated data. With this memory strategy, the subject was able to relate each imaged bit of information to the next most logically related portion of information during information processing. Encoding new information into a logical taxonomy allows the subject to form a cluster of information that would be logically related

in terms of content meaning, and psychologically related in terms of the individual's meaning interpretation. This newly formed cluster of information tends to be more stable and clear than memory traces without a taxonomic interrelation of information. Additionally, the formation of a mental hierarchy of information will tend to facilitate the search and decision process during information retrieval of the available memory store. The theoretical basis for the hierarchy strategy stems from two research conclusions. First, what is stored in memory tends to be stored in a network fashion. Secondly, by imposing a hierarchy structure on input material during encoding, subsequent search and decision activities leading to the effective retrieval of available information tends to be facilitated.

The external variable examined in this study was the visual stimulus complexity variable. There were three levels of the visual complexity variable ranging from simple to complex in visual design. The visual display levels constituted the visual portion of three slide-tape instructional programs making up an instructional presentation about the human heart. The relevant to-be-learned academic information presented in each program was identical. In the 3 instructional programs, the three levels of visual complexity varied only in the amount of irrelevant data contained in the visual display. The first level of the visual complexity variable consisted of line drawings of the heart and its appropriate parts. This level was labeled the simple visual display, the majority of focal information in this visual display was relevant information. The second level

of the visual complexity variable was the intermediate visual display and consisted of a detailed color illustration of the heart and its parts. In this visual design, relevant focal information and irrelevant focal information were approximately equal in amount. The third level of the visual display was the complex visual design. The complex visuals were realistic photographs of a dissected heart. The complex visuals contained more irrelevant focal information than relevant focal information, relevant focal information tended to be embedded in the surrounding visual context of irrelevant information.

An additional area of interest in this study was the retnetion of information over time. It seems likely that if learners can be taught to use effective learning strategies that facilitate the acquisition and retrieval of learned information, the delayed retention of data would be improved. The delayed retention was examined in this study after a period of one week.

I would now like to provide a brief overview of the theoretical and experimental literature in the area of cognitive learning strategies.

The human learner will develop information processing strategies during development by the interaction of the genetic self and the social environment. Such natural information processing strategies are referred to as cognitive styles (Kagan, Moss, Siegel, and Hunt). Natural processing strategies of this type have also been referred to as executive systems (Gagne). Gagne implies that all aspects of the cognitive self are controlled by such

cognitive strategies. These natural information processing strategies seem to be quite permanent in nature. Rigney has investigated the relationship between internal cognitive information processing functions, natural learning strategies and training learners on general learning strategies and concluded that a learning strategy approach to improving learning would be effective. Rigney notes "Self-imposed cognitive strategies are always alternatives to instructional systems with built-in instructional strategies of which the student is never aware. Teaching students how to learn and how to retrieve what has been learned, as the primary objective might in fact, be done best by an instructional system, and having been taught these skills, students might profit more from an instructional system with the primary objective of teaching content."

Investigating strategies and learner ability Goldman and Hudson compared high, middle, and low quality point average subjects, and concluded that learners differed on type of strategy used to acquire information but not necessarily on ability levels. This result implies that strategies are critical in determining academic success. In a discussion of learning skills, Bower feels that schools should teach memory and retrieval strategies as a part of the curriculum, he notes that such strategies are as critical for intellectual development as learning basic subjects. Dansereau, Actkinson, Long, McDonald found that an exclusive concentration on instructional techniques may force learners to adopt non-transferable or inadequate learning strategies. Dansereau, et. al., defined a learning strategy as a method of cognitively

selecting, storing, manipulating, managing and outputting information. This definition implies that a learning strategy is actually a tool to aid the learner in effectively encoding and retrieving learned information. Dansereau designed three learning strategies based upon experimental work in mathemagenics, meaningful learning theory and imagery mediation. Of the three strategies designed and tested, the paraphrase strategy based upon advance organization, and the imagery strategy, based upon imagery representations of stimuli proved highly successful.

Of specific interest to the present investigation is that the use of imagery learning strategies has been found to be promising by a number of researchers in producing significant facilitative effects upon learning. Danner and Taylor found that their relational imagery condition proved most effective in learning paired-associates. Relational imagery subjects were instructed to form an image of the pair that would relate the stimulus and response terms in some way. This condition proved most effective over an integrated illustration presentation of the pair and an integrated illustration plus imaging the illustration condition. Their results may be interpreted in terms of a more meaningful learning of information when the subject was generating his own particular image between pairs. Similar results were reported by Persensky and Senter who instructed subjects to generate bizarre imagery. In a prose learning study, Rasco, Tennyson and Boutwell found that instructions to form an image, or the presentation of an illustration, significantly increased learning over the control. This result may be interpreted as showing that a similar cognitive process occurs, evoking of sensory imagery,

during imagery strategy use, or during the perception of a pictorial presentation. Dealing with a sentence learning task, Anderson and Hidde reported an interesting and unexpected result using as their experimental design an incidental learning task. Subjects were asked to rate thirty sentences, allegedly for some future experimental study. One group was asked to rate the sentences for verbal meaningfulness, (verbal group), the other group was asked to rate the sentences for image evoking potential, (imagery group). After the assigned task was completed, a surprise comprehension and retention test was given about sentence content. The imagery group produced a dependent mean score three times higher than the verbal meaning group.

Research with content-independent imagery learning strategies has generally concluded that strategies can be effective in significantly facilitating information processing. However, current trends in the schools are still towards more traditional uses of external instructional strategies rather than internal cognitive learning strategies. Weinstein noted, "We tell our students what to learn but we say nothing about how to go about learning. The assumption that the abilities involved in learning are either innate or naturally acquired by every child is probably incorrect."

As I mentioned earlier, the experimental design implied a 3 x 3 x 2 mixed analysis of variance with two between-subjects factors and one within-subjects factor. The first between-subjects factor was type of learning strategy (copy, relational and hierarchy). The second between-subjects variable was visual stimulus complexity (simple visual design, intermediate visual design, and complex

visual design). The within-subjects factor was retention of information over time (immediate and delay of one week).

Two dependent measures were used for data collection. These measures represented different types of information the learner had to acquire from the instructional materials. A cued recall measure was used in the form of a forty item multiple choice examination, this measure was called the Terminology and Comprehension test. The Terminology and Comprehension test measured the amount of general concept information, e.g., conceptual information, acquired from the slide-tape instructional program.

The second dependent measure was a free recall measure. This measure was called the Drawing test. The drawing test required the subject to develop a rough sketch, from memory, of the heart. The drawing test was scored in three different ways, yielding three individual sets of data:

1) drawing test part I; Name Part/Any Placement
2) drawing test part II; Part Named/Error of Placement
3) drawing test part III; Adjunct Relationships of Parts.

Each part of the drawing test represents a measure of a different level of information that could be acquired from the visual instructional display. Part I, Name Part/Any Placement, represented a simple list learning information processing task. In this case, the subject had to acquire the names of the parts of the heart only, and be able to list them on his or her heart sketch. Part II, Part Named/Error of Placement, represented a spatial learning task. The error of placement score was derived by tallying the number of parts of the heart correctly named but incorrectly placed

on the subject's heart drawing. This measure identifies an additional aspect of information processing beyond retention and recall of a list of names. In this case, the subject must not only learn the part name, he or she must also learn its correct location within the set of all parts. This learning task represents a higher level of, or more difficult, learning than simply learning the list of parts since now spatial information must also be acquired. A low error score indicates that the subject tended to acquire the location information and a higher error score is indicative of the inverse. Part III of the drawing test represents a measure that evaluates information acquisition at a more difficult learning level than list learning (Part I) or spatial learning (Part II). An additional level of information must now be acquired; "how each part of the heart functionally relates to the next most adjacent part during heart operation". For Part III, subjects were required to indicate on their heart sketch parts of the heart that functionally related during heart operation. The understanding of these "part-to-part" relationships and "among part" relationships represents a conceptual knowledge of the basic operations of the heart during the diastolic and systolic phases of operation. This relational concept knowledge is clearly a different level of information processing than list learning or spatial learning, and a more difficult learning level.

I won't go into a detailed discussion of the experimental procedures, subjects and apparatus. Additionally, at the present time, a comprehensive review of the resulting data sets would be far too time consuming. However, I will provide you with a general

overview of the results, in terms of discussing the dependent measures and independent variables and their effects. Also, I would like to mention that a complete presentation of the study can be found in an upcoming issue of Journal of Experimental Education, Fall or Winter 1982.

Although all three strategies used imagery representations as an information processing mode, they varied in the amount of cognitive organization imposed on encoded data. The hierarchy strategy resulted in the most effective information processing of the three strategies. The hierarchy strategy was significantly better on the Spatial Learning task (Part II-Drawing Test), the Relational Concept task (Part III-Drawing Test), and the Terminology and Comprehension test. No differences occurred on the list learning task. This implies that subjects using the hierarchy strategy had a significant information processing advantage. It is likely that this processing advantage resulted from the condition of storing new information in a logical network or hierarchy of data. During encoding, this condition permitted a more efficient assimilation and accommodation of new information. An efficient encoding stage would allow the hierarchy strategy to overcome the debilitating effects of increasing visual complexity. This may explain the hierarchy strategy's significant effects on the Terminology and Comprehension test regardless of Visual Display Complexity and Time, resulting in the Second Order Interaction. Increased visual complexity increases abstraction time and effort and therefore, decreases available encoding time. The only compensator for this condition would be a more efficient encoding stage during

information processing. The network cluster of data would also provide for established retrieval cues to facilitate the recall of information within the cluster. The retrieval cues in this case may have consisted of the superordinate information in the stored network. Additionally, once this single network of information was retrieved, the available data in this network would tend to become more accessible, so retrieval was not a matter of a search and decision through the entire memory store, but a matter of recalling a single network of data. After this network was retrieved, it is probable that subsequent retrieval activities consisted of carrying out a search and decision through this single stable and clear cluster of interrelated data.

The relational strategy used as a basis imagery mediation having the processing advantage of dual-coding. This strategy provided for the additional processing advantage of a peg-mnemonic system, making pre-learned information available in the cognitive structure to facilitate future learning. This condition provided a cognitive context to relate new information to form the instructional program. During encoding, new data could be efficiently assimilated to the cognitive structure because of this prelearned available information. The relational strategy differed significantly from the copy strategy on Part III of the drawing test. This difference approached significance on the Terminology and Comprehension test. However, the two did not differ on Part I or Part II of the drawing test. The peg-mnemonic system using imaged cognitive pegs, was a slightly better information processing strategy than the copy strategy, employing only dual-coding as an information processing advantage.

The copy strategy had the processing advantage of dual-coding via imagery mediation. This allowed the subject to store an imaged code and a complementary propositional code. Multiple encodings of this type prove to be effective devices to facilitate learning. The copy strategy had the disadvantage, however, of a "global" processing; in other words, the subject imaged the entire visual display and attempted to store it globally in memory. This meant that the subject had to store all information, both relevant and irrelevant. Besides eliminating the opportunity for restructuring, this may have placed a considerable cognitive strain on the memory system.

The three strategies produced differential effects during information processing. All strategies had as their representational basis, of perception, imaged mediation. The difference in learning effectiveness appears to occur as a result of differences in the cognitive organization of processed information. As a more effective cognitive organization of information was provided for by the hierarchy and relational strategies, improved learning outcomes occurred, especially for the more difficult levels of the information processing tasks (e.g., general concept learning on the Terminology and Comprehension test, and relational concept learning on Part III of the Drawing test).

The external domain of instructional design considers how materials are to be sequenced and mediated. This is a critical consideration when making decisions about solving instructional design problems. The results of this study in this regard generally complement the findings of classical research in this area. The simple visual display provided for the most effective and efficient

information processing. This display contained essentially relevant information with enough background to give a logical context to the drawing. The simple visual display tended to minimize the abstratcion process and permitted the subject to put more time and effort into encoding the information. The intermediate visual display contained an approximately equal amount of relevant and irrelevant information. This tended to make abstraction more difficult, because of this the intermediate visual display was less effective than the simple. The complex visual display contained more irrelevant than relevant information, this condition would tend to cause a debilitating effect to occur on information processing. The complex display required a maximum abstraction time and effort. By maximizing the abstraction effort, the encoding stage of information processing suffered. This situation may have caused less relevant data to be ultimately encoded into the cognitive structure. The most effective external conditions for focal materials are those requiring a minimum of abstraction (e.g., separation of relevant from irrelevant) by the learner.

This study implies that instructional system researchers should consider both the external and the internal conditions of learning and specifically research in cognitive areas. Future research in the area of learning strategies should consider the design and refinement of various types of cognitive learning strategies. The basis for developing these strategies should be functionally related to the organic mediational processes occurring in the cognitive structure during information processing. Additionally, external conditions should be evaluated relative to their

effectiveness when certain types of learning strategies are used. Once learning strategies have been designed, tested, and refined, they should become a critical part of the learning of school students in the primary years of intellectual development. Learning strategies should become second nature to students in a similar way that the recursive rules of multiplication have become second nature. At present, this critical variable in learning ability, acquiring effective learning strategies, is left to haphazard development by the learner. Although researchers in instructional systems are approaching the issues related to internal cognitive facotrs and their specific affects upon learning, as Weinstein has indicated, much is left to be accomplished.